CHAPTER 8

Extreme Environment Operations

Section I

DESERTS

CHARACTERISTICS

Deserts are semiarid and arid regions containing a variety of soils in varying relief. Desert regions are characterized by:

- Extreme temperature ranges, varying between 30°F and 130°F over a 24-hour period.
- Changing visibility conditions.
- Long periods of drought, interrupted by sudden rains that bring flash floods.
- shortages of suitable ground water and virtually no surface water.
- Large areas for excellent movement, interspersed by ravines, bogs, and sand seas.
- An absence of pronounced terrain features.

SURFACE FEATURES

The basin-and-range topography typical of most desert regions is characterized by great, waste-filled valleys separating high mountain ranges. Many such valleys are interior basins with no river outlets. Streams running down the mountains lay coarse, fan-shaped alluvial deposits along the sides of the mountains and into the valleys. Most of the down-flowing water sinks and disappears into these deposits. In these valleys, you can find a permanent zone of saturation in the lower part of the valley fill. Tap this water by use of wells. The water from the upper slopes that does not sink into the deposits or is not lost by evaporation is carried by interior drainage into the lowest parts of the closed desert basins where it collects. This water is discharged to the atmosphere by evaporation, leaving salt concentrations near the surface. In locating a water supply of good quality in a basin-and-range desert region, the main problem is to avoid the common, salty water.

Playas or playa lakes are the barren clay flats resulting from the muddy accumulations which collect in the low basins and become dry after losing water by evaporation or seepage. The playas are smooth and flat and have a lake-basin type topography. The water held in the subsurface sediments keeps the surface of some playas moist. Where subsurface water escapes downward through openings in bedrock below the sediments, they are dry except after rains. Saltwater generally occurs near the surface in most playas, but fresh water may underlie it.

Other desert regions, such as those in parts of northern Africa and interior Australia, occur on high plateaus without mountain ranges. Such regions lack the deposits of alluvial sediments and receive very little rainfall. Supplies of ground water near the surface are rarely available. The only possible source of water is aquifers which transmit water from distant intake areas. If a geologic reconnaissance indicates the presence of such an aquifer, test drilling to tap it may be justified.

GROUND WATER

In desert areas, there may be undeveloped water supplies at depths of several hundred feet. Depending on your location in the desert basin and the presence of other indicators, test drilling to depths below those reached by native wells may be justified.

Occurrences

The typical desert basin can be divided into three principal parts according to ground water occurrence: the mountain range which contributes most of the runoff but has little ground water; the upper alluvial slopes, consisting of coarse debris and containing ground water at considerable depths; and the valley fill in the lower parts of the basin, which contains most of the ground water. The water in the central part of the basin is often salty. The quality of water obtained in the mountains is good but quantities are generally very small. You can obtain fresh water in the alluvial slopes by placing wells to depths of several hundred feet. Test drilling is necessary in unexplored basins because the thickness and character of deposits vary from place to place.

Indicators

Plants are extremely valuable as water indicators in desert regions. Experience has shown that various species of ground water plants not only indicate the presence of water but also its quality and approximate depth below the surface. Some species of plants reach water at or near the water table, but most plants get their water from the soil moisture above the water table. In arid regions, the presence of plants that tap the water table indicates that ground water is close to the surface. In more humid regions the greater abundance of water in the soil reduces the value of plants as indicators of a high water table. Ground water plants sometimes obtain water from a perched water table in which case the available water supply may be limited. Ground water plants generally occur in a zone around the central playa of a basin but not in the center itself because of the alkaline clay at the surface. Generally, plants other than cacti, sagebrush, and the yuccas will not grow unless there is a subterranean water table within 25 feet of the surface. Exceptions to this would be certain southwestern U.S. phraeatophytes which are known to draw upon ground water from depths in excess of 100 feet.

OPERATIONS

Combat operations in the desert pose a number of unique problems. Because there is so little water and because soldiers and equipment cannot survive without it, water is a critical item of supply in the desert. Forces trying to survive in the desert without adequate water supplies have always met with disaster. Finding and keeping water sources may be the crucial issue in desert conflicts. At the very least, water sources will be critical.

Surface Water Sources

The principal problem of water supply units in desert operations is lack of surface water sources. Although water supply units normally operate as far forward as possible, available water sources may force water supply units to operate further to the rear than normal.

Camouflage

This is another problem in desert operations. Lack of vegetation requires extensive use of camouflage nets, patterns, mud paintings, and covering of reflective surfaces to conceal water supply point operations.

Heat Stress

This is also a critical problem for soldiers working in a desert environment. Operation of water points in daytime temperatures means short periods of work followed by long periods of rest. Operation at night, to avoid heat stress, creates light discipline problems which may be unacceptable, considering how easy it is to see in desert regions. To conserve water in desert combat, greater reliance is placed on conservation procedures. However, water requirements are much greater. Therefore, you must increase resupply rates.

MAINTENANCE

The desert environment requires a very high standard of maintenance performed well away from specialized support personnel. Operators must be fully trained in operating and maintaining their equipment. Dust, sand, and wind are probably the greatest danger to the efficient functioning of equipment in the desert. It is almost impossible to avoid particles settling on moving parts and acting as an abrasive.

Lubrication

Lubrication must be the correct viscosity for the temperature and must be kept to the absolute minimum in the case of exposed or semi-exposed moving parts. Sand mixed with oil forms an abrasive paste. Lubrication fittings are critical items, Check them frequently. If they are missing, sand will enter the housing and cause bearing failure. Teflon bearings require constant inspection to ensure that the coating is not being removed, Maintenance of engines is critical due to the strong possibility of sand or dust entering the cylinders or their moving parts when the equipment is stripped. It is essential to have screens to protect against flying sand. All tools must be kept clean and free of oil film and sand / dust. In hot climates, the film of oil necessary for operation and preservation will quickly disappear. Inspect equipment daily, paying particular attention to hidden surfaces and other likely places where corrosion might occur and not be quickly noticed. Perspiration from the hands can cause rusting. After handling the equipment, clean it, wipe it dry, and lubricate it.

Filtration

It takes comparatively little dirt to block a fuel line. Compression-ignition engines depend on clean air. Examine and clean air cleaners on every type of equipment at frequent intervals. The exact interval depends on the operating conditions but should beat least daily. Use filters when receiving fuel. Cover the gap between the nozzle and the fuel tank filler. Fuel filters will require frequent cleaning. oil filters will require replacement more frequently than usual. Engine oils will require changing more often than in temperate climates.

Electrical

Wind-blown sand and grit will damage electrical wire insulation over a period of time. Protect all cables that are likely to be damaged with tape before the insulation becomes worn. Sand will also find its way into parts of items such as spaghetti cord plugs, either preventing electrical contact or making it impossible to join the plugs. Carry a brush, such as an old toothbrush, and use it to brush out such items before they are joined.

Section II

COLD ENVIRONMENT

NORTHERN REGION CHARACTERISTICS

Northern regions, including the Arctic and subarctic, comprise about 45 percent of the North American continent and 65 percent of the Eurasian land mass. Northern regions are characterized by—

- Extreme cold and deep snow during winter months.
- Spring breakup, resulting in poor movement.
- Whiteout and grayout which cause loss of depth perception, making flying, driving, and skiing hazardous.
- Ice fog in which clouds of ice crystals cover troops, vehicles, bivouac areas, and permanent facilities, marking their location.

The winter battlefield is characterized by an environment that is at best hostile. Depending on the distance north or south of the equator, the amount of daylight is significantly less than what occurs during the summer months. The Arctic and Antarctic circles are at the latitudes beyond which there is at least one day per year where the sun does not rise above the horizon at sea level. This results in total darkness at those locations when it occurs. The temperatures on the winter battlefield range from 35°F above zero to 50°F below zero, depending on the latitude and the elevation at a particular location. Precipitation on the winter battlefield can be in the form of rain, freezing rain, sleet, snow, or any combination of these. The amount of winter precipitation can vary over a large range within a few hundred miles depending on such factors as the terrain, elevation, and proximity to large bodies of water such as oceans.

NORTHERN REGION OPERATIONS

Operations in these areas are affected by various conditions. They are discussed in the following paragraphs.

The selection, development, and proper operation of a water supply point in the northern regions require an understanding of conditions peculiar to these areas. When temperatures go below 32°F, water purification personnel have difficulty operating and maintaining their equipment. Constant winterizing and use of the water heaters are required to prevent freezing. Winterizing, however, is not always feasible. Surface water in winter must be pumped from beneath an ice layer. To prevent freezing, it may be necessary to preheat the water during operations and keep it heated until it is issued. In addition, water purification equipment is not as effective when the temperature reaches 32°F. At this point, ROWPUs produce less than half of their rated production capability. Treatment chemicals also react differently at extremely low temperatures. For example, at 32°F, chlorine requires twice as much contact time to properly disinfect water.

Water reconnaissance is adversely affected by extreme cold. Electronic instruments, such as radiacmeter and automatic chemical test kits, become less dependable and may even fail. In the case of NBC operations, chemical detection and identification kits cannot detect solid agents. It may be necessary to take soil, snow, or vegetation samples from suspicious areas and warm them to detect and identify chemical vapors.

SOURCE DETECTION

The first step in any water supply operation is to find a source of water. On the winter battlefield, the priority is to use surface water sources whenever possible. The biggest problem is to find unfrozen water under a cover of ice and snow. In some areas it is very easy to find rivers, lakes, and ponds by simply reviewing maps and conducting a visual reconnaissance. In other areas with heavy snow covers, it is very difficult to distinguish small bodies of water from the surrounding terrain. In this case, the presence of vegetation on the shoreline or small changes in elevation maybe the only indications of an ice- and snow-covered pond or lake.

Once you locate a body of water, it is important to know the thickness of its ice cover and the depth of the water under the ice cover. Shallow surface water sources freeze to the bottom during the winter months. The ideal situation would be to have an ice cover about 6 inches thick with at least 5 feet of water under it. Fast-moving water does not freeze as fast as slow-moving water under the same temperature conditions. Fast-moving water occurs in rivers and streams wherever there is a reduction in the width of the river or stream. Another place to look for fast-moving water is on the outside of bends in the river. Other than using a motorized ice auger to bore a hole in the ice to measure its thickness and the depth of the water underneath it, the most efficient tool to use is a hand-operated ice auger like the type used by ice fishermen. This type of ice auger is much faster and safer to use than an ax or ice chisel. It also has the advantage of being much quieter and lighter than a motorized ice auger. Once you bore a hole through the ice, use a stick with a piece of wood perpendicular to its end to catch under the bottom of the ice cover to determine the ice thickness. Use another stick with depth markings as a gauge to determine the depth of water under the ice cover.

If the hole in the ice has been cleared of floating ice particles and it refills with a lot of slush y ice, it means that it is in an area where frazil ice is being transported under the ice cover. Frazil ice is the slushy ice that forms as the water travels in turbulent unfrozen sections of a river. If the water supply hole is located in an area of the river where frazil ice is being deposited, it may result in the frazil ice being sucked into the raw water pump, causing it to freeze.

Shallow ponds and lakes are relatively quiet bodies of water compared to rivers and streams. Therefore, the growth rate of ice on a lake or a pond is faster than on a river. This means that a foot of water under ice on a pond will freeze much faster than a foot of water under ice on a river. As small ponds and lakes freeze, most of the dissolved minerals are excluded from the ice that forms. This means the dissolved minerals remain in the water. As the ice cover on a pond or lake grows, the concentration of dissolved minerals in the water increases. For example, if a pond had 2 feet of water with a total dissolved solids concentration of 1,000 mg/l under an ice cover and the ice cover grew so that there was only one foot of water left under it, then the concentration of total dissolved solids in the remaining water would be about 2,000 mg/l. This is important as the TDS of the source water has an impact on the pressures required to operate the ROWPU. Also, as the temperature of the water drops, so does the production rate of the ROWPU. With decreasing temperature and increasing TDS, water production rates drop and maintenance requirements increase.

The other source of raw water is groundwater. The detection of groundwater is more difficult on the winter battlefield because of the presence of either seasonally or permanently frozen ground. The physical and chemical characteristics of frozen ground are different from unfrozen ground. This means that the various techniques used to detect the presence of groundwater in unfrozen ground have to be adapted or modified in order to detect water that is either under or in frozen ground. Because groundwater exists only in unfrozen soil, look for unfrozen ground in or under frozen ground.

Things such as icings or ice mounds indicate the presence of shallow groundwater. Icings are large, relatively thin sheets of ice that occur when groundwater seeps to the surface and freezes as it flows across the ground. Ice mounds are large mounds of soil and water that sometimes form on relatively flat areas. Often they are as tall as a person and are present in randomly spaced clusters. Both icings and ice mounds indicate the presence of shallow groundwater. They can serve as a source of water for small units and individual soldiers as well as an indicator of a groundwater source you can develop for water point operations.

SOURCE DEVELOPMENT

When possible, locate lake and river water points on the leeward side where there is generally clearer water, less snowdrifts, and more shelter from the wind. Locate sites on a lake as far from the shore as possible, within effective camouflage limitations.

The development of a surface source of raw water on the winter battlefield usually consists of drilling a hole through the ice cover, and, in some cases, putting an insulated cover over it to prevent it from refreezing. In very cold weather, it may be necessary to periodically drain the raw water pump and the raw water hoses and bring them into a warm shelter so they do not freeze. This means that the pumps and hoses will have to be carried up the river bank. Make every effort to select a site where the river bank will not be too steep to walk up without falling when it is covered with snow. If this cannot be avoided, push the snow over the bank to form a more gently sloping ramp from the river.

Snow is a good insulator. Because of this, it should not be cleared from the ice around the water supply hole. This snow will serve as an insulating blanket and slow down the growth of ice under it. In the extreme cold, this loss of insulation could result in a shallow river freezing solid. As a result, you would have to find a new source of water and move the water supply point. The ice usually will be thinnest where it is covered by the most snow. Snow can be put into sandbags and used to build a shelter over the supply hole to prevent it from refreezing between uses. Use this same shelter to house the raw water pump to keep it from freezing.

The development of groundwater raw water sources on the winter battlefield is primarily concerned with drilling wells. Well drilling is covered in FM 5-166 and is not discussed in detail in this manual. Frozen ground adds an additional factor to be dealt with by the driller. In addition to drilling the well, the driller may have to case the well to prevent the sides of the hole from collapsing. Also, you must shelter the piping and the pumps that are above the ground surface against the cold. Because of the amount of equipment and time required to develop a groundwater well, surface water sources should always be the first priority as a source of raw water for water point operations. Groundwater wells are normally associated with rear area semipermanent or permanent facilities.

SETUP

Once you have found and developed the source of water, the next step is to set up the water purification equipment and the product water storage and distribution equipment. Depending on how cold it will be, it may be necessary to erect a tent to house the water purification unit and storage and distribution equipment. Place tents used to house the ROWPU on the ice, directly over the hole through which water is pumped or as close thereto as possible to reduce the possibility of water freezing in the intake hose. The type of tent required depends on the type of tent available in your unit. Depending on the number of product water storage tanks deployed, it may be necessary to extend the tent with additional sections if you are using the TEMPER or put up another tent for the additional tanks. The best method is to use TEMPERs that are extendable to a desired length.

Heating the tents requires using Herman Nelson, Bare Base, or other types of heaters. The number and types of heaters will depend on the allocation in your TOE. Maintain the temperature in the tent high enough so that the operators can work comfortably without wearing heavy outer clothing such as parkas or field jackets. On the other hand, the tent should be cool enough that the operators can work in it without perspiring. Perspiring will result in chills when operators go outside. At least one more heater than what is required to maintain a comfortable working environment in the tent should be available at the water point for backup. It is important that this backup heater be available at the water point and not stored in a supply area some distance away. If it is not readily available, it is possible that the temperature in the tent could fall below freezing if the heater in use failed or had to be shut down for maintenance.

When placing the water supply equipment in the tent, keep in mind that the warm temperature in the tent will thaw the frozen ground. This means two things: one, mud will form around the tanks; second, the tanks and equipment may freeze to the ground. In this situation, place the water storage tanks on pallets to serve as walkways for the operators. Store all chemicals off the ground on pallets.

Use cribbing under the leveling jacks of the water purification equipment to prevent them from sinking unevenly into the ground when it thaws. Place planks under wheels of the water purification equipment to prevent it from getting stuck in the mud when it is time to move to another location.

When the ROWPU is set up inside a tent, attach tubing to the vent and drain lines. Empty this tubing into a container so that the water will not spill on the ground in the tent creating more mud.

Another problem you may encounter with frozen ground is grounding the electrical generators used to power the equipment. This problem has two parts. First is the problem of actually getting the ground rod into the frozen ground. The second is the problem of getting a good electrical ground in the frozen soil. In some situations, it will be impossible to drive a ground rod into frozen soil. If this occurs, bore a small hole into the soil with a soil auger, or use a shaped charge explosive to blast a hole in the frozen ground for the ground rod. Reduce the electrical resistance to the ground caused by the frozen soil by pouring a strong salt solution down the hole around the ground rod. A solution made from one pound of salt dissolved in one gallon of water will work well. While the water supply point is being set up, you must consider its survivability on the battlefield. Deploy camouflage nets whenever they are available. Take care that they do not freeze to the ground, especially in areas where water spills and ice forms. Snow is an excellent camouflage material on the winter battlefield. It is also an excellent material for the construction of field fortifications because of its ability to stop rounds from small arms and crew-served weapons.

In extreme cold, the water vapor contained in the exhaust from generator engines and other engines forms ice fog which becomes a signature easily detected by the enemy. To reduce ice fog, cool the exhaust before it is released into the atmosphere. Attach flexible steel pipe to the exhaust, and lay the pipe in a snow bank, covering it with tarpaulin. This cools the exhaust which subsequently reduces the formation of ice fog.

OPERATIONS

Once the water supply equipment has been set up, the next step is to make potable water. On the winter battlefield, there are the additional complications of keeping the water from freezing and the effects of the cold raw water temperatures.

One of the characteristics of cold water is its increased viscosity. Viscosity is a measure of the stickiness or the ease with which water flows. At the lower temperature, water is more viscous or sticky than it is at warmer temperatures. This means that at lower water temperatures a specific pump will pump less water per minute than it does at a warmer temperature. It also means that solid particles will settle slower in cold water than they will in warmer water temperatures. As a result of the viscosity effects of cold water normally found on the winter battlefield, the production rates of water supply equipment will be reduced.

Another characteristic of cold water is that it slows down the rate of chemical reactions significantly. This means that the reactions that occur when chemicals, such as polymer, are added to cold water will take longer to complete than they do in warmer water. Therefore, you must slow the flow rate of water through the equipment where these reactions take place so that the reactions can be completed and the water treated. Notice the reaction of chlorine when it is added to the product water to disinfect it. The ability of chlorine to disinfect the product water by destroying disease-causing microorganisms, such as bacteria, is significantly reduced at cold water temperatures. At water temperatures below 49°F, a solid material known as chlorine hydrate begins to form when chlorine is added to the water. When this occurs, some of the chlorine is removed from the solution and its disinfecting capabilities are reduced. For chlorine to be most effective as a disinfectant, the water temperature should be above 50°F.

Spillage of water around a water point can become a serious safety hazard because it may freeze into a sheet of ice. Sheets of ice on the ground can cause personnel to slip and fall and can cause vehicles to skid and slide into equipment or personnel. If ice forms, increase its traction by putting sand or ashes on it. Make every effort to limit the formation of ice.

Extend all lines used to pump brine, filter backwash water, and any other types of wastewater from the water treatment equipment far enough from the tent so that ice will not be a safety hazard. If possible, place a rope or engineer tape around the area where the ice forms so personnel will not walk on it at night. Locate wastewater drains in an area where the water will not drain back into the tent. If this happens, it is possible that the tent will freeze to the ground. Then you will have to cut the tent out of the ice.

When raw water pumps are being set up, prime them with warm water. After use, drain them immediately and bring them into a warm tent so that the remaining water will not freeze. Do the same thing with the raw water hoses. Disconnect them, drain them, and bring them into the tent. When draining the raw water pumps and hoses, drain them back into the supply hole and not on the area around it. Allowing the water to run over the snow around the supply hole will result in a safety hazard for the operators, and it will reduce the insulating value of the snow, allowing the ice underneath it to grow quicker and reducing the amount of unfrozen water under it. Remember to drain the pumps and hoses and bring them into the warm tent between uses.

600-GPH ROWPU PROCEDURES

The 600-GPH ROWPU has no built-in cold weather protection. Operate the 600-GPH ROWPU within an enclosed and heated environment (TEMPER). To deploy or move the ROWPU from one operational site to another, drain the 600-GPH ROWPU as follows:

Drain the ROWPU's pipes, filters, and connections by opening all seven drain valves and all five vent valves. Facing the trailer from the towing end, jack up the left side to permit maximum water drainage through the drain valves.

After the water has stopped flowing from the drains, set the RO Pump Jog switch to Jog. Hold it there for three to five seconds to force water from the pump. Remember not to operate the RO Pump Jog switch for more than five seconds at a time as you can damage the pump. **(NOTE:** The Jog switch can be used when the RO pump Low Pressure lamp is on.) Repeat this operation until no more water comes from the Drain Pulse Dampener drain. Disconnect the plastic tubing from the bottom of the RO vessels so they can drain. Reconnect the tubing when the vessels are fully drained. Also disconnect the six plastic connectors holding the plastic lines on the backwash valve assembly timer on the multimedia filter and allow the lines to drain. After draining the lines, reconnect them to the valve assembly.

Drain the booster pump by running the Booster Pump switch, but for no more than five seconds at a time. Repeat until no more water comes from the cartridge filter drain.

Drain all chemical feed pumps by first emptying and rinsing all chemical containers and filling them with brine water. Next, set the chemical pump valves to Prime. Set all the control knobs to the maximum setting and run the pump motor to rinse the chemical pump. Chemicals can cause sickness or death if extreme care is not taken. Wear protective devices when working with these solutions. Remove intake hoses from all chemical containers. Use care in removing intake and discharge hoses from the chemical feed pump head. The plastic hoses are extremely brittle and are easily broken. Set the pump to run for 5 to 10 seconds to empty water from the chemical pump. Stop the pump motor, empty the chemical containers, and set the pump valves to the off position. Remove all hoses from the pump and drain.

Drain the distribution pump and raw water pumps. Disconnect the inlet and outlet hoses. Tip the pump toward each connection to permit drainage. Open the pump vent and drain valves.

Run the pump for five-second intervals until all water is out.

Drain the backwash pump by disconnecting the suction hose and unscrewing the drain plug on the bottom of the pump. After all water is drained, replace the drain plug.

When the ROWPU is shut down, remove the RO elements and soak them in a 1 percent formaldehyde solution for five minutes. Store the elements in plastic containers indoors or in a tent where the temperature is above freezing. Do not allow them to dry.

3,000-GPH ROWPU PROCEDURES

The 3,000-GPH ROWPU has cold weather protection built in. The winter kit has other needed items. When the unit is on deployment, avoid freeze-up. Drain the equipment to avoid damage from ice formation; however, if allowed to freeze, two to three days will be needed to thaw out the critical equipment before resuming operations.

Built-in Features

Built-in features include an insulated and weather-sealed container, floor drain sumps with electric heat tracing pads, and two diesel-fueled space heaters. Each heater draws fuel from the diesel generator fuel tank at 1/6 gallon per hour. The 24VDC electrical power is provided from the diesel generator batteries or through the AC/DC converter when the generator is operating and the main control panel heater switch is on. If not powered through the AC/DC converter, power draw is automatic from the diesel generator batteries. At -25°F, one heater may safely be powered for one hour without risk of excessive battery discharge. Other built-in features include an auxiliary power connection. This connection is for an external 120VAC power supply. With the heater and heat trace switches on, this will power the space heaters through the AC/DC converter, the pump heaters, and the sump heat tracing. Finally, the media filter and NBC filter both include a connection to use ROWPU air to rapidly purge the water from these filters to avoid severe freeze-up.

Winter Kit

The winter kit includes two electric hot air blowers, one for the distribution pump and one for the raw water pump. These blowers connect to heater outlets at each side of the ROWPU and provide heat to the inside of the pump casings when the pumps are not operating. Also included in the kit are glow plugs for each of the diesel heaters inside the container, a nonfloating intake screen for use when taking water from an ice hole, and a cable to connect one of the diesel heaters to the generator battery during transport or when the power to the ROWPU is off.

Operations

Avoid freeze-up of the RO vessels and elements during deployment to assure continued ROWPU operations. Use the space heaters to maintain ROWPU van temperature over 35°F. Do not exceed the time limitations established in TM 5-4610-232-12 without heat. Draining will avoid freeze-up of feed and waste pipes which may generate damaging ice pieces upon start-up. Draining does not remove all water from the vessels and RO elements. The RO elements hold some water after draining. If ice is present in the RO elements or vessel when the ROWPU is started, the elements may be damaged. Damage is noted by a high product water TDS because of water passing directly through holes in the membrane material. If RO vessels and elements are drained and allowed to freeze, thawing will require two days with additional heat provided to bring the temperature up to 85°F or eight days at 45°F. If freezing cannot be avoided, remove the elements, stand them on end to assure drainage, and properly seal them.

Both the polyelectrolyte and sequestrant will freeze but will not lose performance when thawed. Completely thaw before using them. If they are cloudy, mix them before using. The chemical tubing will freeze in the chemical systems if not purged. Damage is unlikely. However, thawing will delay availability. Provide protection by air purging according to long-term shutdown procedures.

Avoid freeze-up of the media filter during deployment to assure continued operation. If freezing cannot be avoided, drain and air purge the filter to avoid solidly freezing the media and internal works. If the filter is drained and allowed to freeze, thawing will require the same time and heat as required for the RO elements. If the filter is drained and purged before freezing, it can be returned to service with some precautions. Treat the NBC filter the same as the media filter.

When deployed for a cold weather mission, the raw water and distribution pumps are enclosed in an insulating casing and the hot air blower is installed. The hot air blower keeps the pump casings warm when the pumps are not operating. While the pumps are operating, the water flow will prevent freezing. When securing the ROWPU or when the diesel generator fails, drain the pumps within 15 minutes.

Flowing water will not easily freeze in the piping, so there is little danger of freeze-up while the ROWPU is running. When the ROWPU is shut down during cold weather, however, water in the pipes can freeze. Expansion during freezing will damage piping. Therefore, drain the ROWPU when it is stored outside in cold weather.

When the ROWPU is running, there is no danger of hoses freezing. The hoses will not freeze rapidly, but ice may build up at the end connectors and begin to restrict the water flow. Covering the hoses with 12 inches of dirt or snow will reduce this problem. Ice will begin to form in the hoses within a short time after shutdown at -25°F. If the ROWPU is to be shut down longer than 15 minutes, disconnect the hoses at all joints and fully drain them by walking out all water. Start-up is simplified if lay-flat hoses are also rolled and placed within the ROWPU until needed.

Shutdown

When shutting down to a secured condition, perform normal shutdown procedures. In addition, the following actions should be taken in cold weather.

While the media filter is being backwashes, remove the product hose sections and the product shut-off valve. Cap the van connection. Immediately after backwashing is complete, close the feed valve, remove the raw water discharge hose and adapter, and install the cap on the van connection. Disconnect all canvas hose sections and quickly walk out the hose sections to remove water. Roll up the hoses and place them inside the van. Disconnect all waste hose sections and walk out the water. Reconnect for use during cleaning procedures. Disconnect and drain all deployed raw water suction hose sections. Open the raw water drain and priming valves.

After beginning the RO cleaning or sanitizing procedure, drain and purge the media filter by opening the media filter lower drain and vent valves. Continue the air purge until only air is observed at the drain. Watch the air pressure gauge. Do not allow pressure to drop below 200 psig. If it does, close the valve and wait for additional air pressure to build before continuing. After the media filter is drained, close the hose valve and leave the filter drain open. If on an NBC mission, drain and purge the NBC filter. When cleaning and/or sanitizing procedures are complete, drain the water tanks, disconnect the hoses, and open the distribution pump drain valve. Immediately roll up the dispensing hoses with the nozzles locked open to remove the water, and place them inside the van. Maintain operation of the space heaters to avoid freeze-up.

Continue to operate the diesel generator to provide power for the heaters. An auxiliary power connection provides 120VAC power to the van and high-pressure pump package space heater as well as to the heat trace and pump hot air blower circuits. Power can be supplied by an auxiliary generator or another ROWPU at the water point, allowing the diesel generator to be secured. The space heater's power automatically shifts to the diesel generator batteries when the generator is shut down and auxiliary power is not supplied. The Heater Power Supply On/Off switch will control the heaters. When drawing from the batteries, stop heater two to avoid running down the batteries. If the ROWPU is being shut down for storage, remove the RO elements after soaking them with sodium metabisulfate. Drain the RO vessels before the heaters are stopped.

Movement

Preparation for movement in cold weather involves the following additional steps. Maintain generator and heater operations until pack-up is complete. Open all vents and drains. Do not leave RO element sanitizing solution in the RO vessels. Uncap all ROWPU van external connections. Air purge the media filter, the NBC filter, and all three chemical systems. Now follow normal pack-up procedures. Stop heater one, close van doors, and secure the generator. The remaining operating heater (heater two) will prevent freeze-up during transport. After one hour, battery drain may be excessive.

STORAGE AND DISTRIBUTION PROCEDURES

Keep any product water being stored or distributed on the winter battlefield from freezing. There are several ways to accomplish this procedure.

Elevate the product water storage tanks on pallets off the ground in a warm tent. If the tanks are outside, keep ice and snow from the top of the tanks. Remove ice and snow from connections to ensure proper assembly and disassembly of components. Avoid any unnecessary folding, unfolding, or rolling of tanks which might cause cracking or damage to the material. At the water supply point, bring product water distribution hoses into the tent when not in use. Personnel at the water supply point should use insulated, waterproof gloves when dispensing water. Be careful when handling hose assemblies and distribution nozzles. Before attempting to use nozzles, remove any accumulation of ice or snow and check for free movement of the nozzle on swivels.

Use pumps to prevent freezing in storage tanks by recirculating water between tanks. The number of pumps required and their location depend on the number of storage tanks used. Keep engine fuel tanks full to prevent condensation. Drain and service fuel filters more frequently than under normal conditions. Before starting engine-driven pumps, remove any accumulation of ice or snow from spark plugs and wiring. Make sure the inlet air temperature shutter on the engine is set for winter operation. Run engines at low speed, and allow them to warm to the operating temperature before applying full loads.